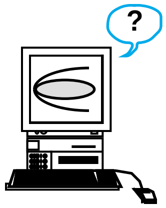

Ask Dr. ALOHA:
Working with the Concentration Graph

Ahmed Ismael, a new recruit to the River City Fire Department's hazmat team, is learning to use ALOHA by reading the manual and working the example problems it contains. Right now, he's trying to be sure that he correctly understands what ALOHA's footprint represents. The manual defines a footprint as "an overhead view of the area where the ground-level pollutant concentration is predicted to exceed your Level of Concern (LOC) sometime after a release begins." That is, ALOHA predicts that at some time, at any particular point within the footprint, the concentration of a pollutant gas at about ground level—where people tend to be—would rise above the LOC. Typically, this would happen shortly after the cloud of pollutant gas reaches that point.

Accounting for Contact Duration

Ahmed notes that although ALOHA's footprint shows where the concentration is predicted to rise above the LOC, it offers no information about how long the concentration at any point might remain higher than the LOC. He wonders whether ALOHA can provide that information.

Ahmed is interested because he has learned that the most commonly-used kind of LOC is an **exposure limit**. Each exposure limit has a specific definition, but very generally, each in some way reflects the effects of a toxic agent on people. In his reading, Ahmed has learned that most exposure limits have a **contact duration** associated with them. An example of an exposure limit is the TLV-STEL (Threshold Limit Value–Short-Term Exposure Limit), a workplace standard sometimes used as an LOC for emergency response. A chemical's TLV-STEL is the maximum time-weighted average concentration of that chemical in the air to which workers may be exposed for **up to 15 minutes**. So for TLV-STEL, the contact duration is 15 minutes.

Just what does this mean? At first glance, the concept of contact duration may seem nonintuitive and technical. An example from early industrial practice may help make it clearer. Years ago, before the toxic effects of mercury were well-known, hatters coated hatbands with mercury before putting them on hats, in order to secure them in place. By doing this, hatters came into contact with small amounts of mercury. Hatters who were in contact with mercury long enough developed "Mad Hatter's Disease," a syndrome that can cause many physical and psychological problems. Typically, because the hatters contacted relatively low concentrations of mercury, it took a few years for the symptoms of the disease to appear. If someone were to come into regular contact with higher concentrations of mercury, it would take less time for health effects to appear. In both cases, contact with mercury doesn't immediately initiate particular health effects; it's necessary for that contact to continue for some length of time. That length of time is shorter when a chemical is more acutely toxic or when it is present at a higher concentration. The reason why a contact duration is associated with most exposure limits is because contact must happen for a length of time in order for health effects to develop. Many chemicals of particular concern to emergency responders, such as chlorine and ammonia, are so acutely toxic that they can be hazardous to people even during a brief period of contact. Short-term exposure limits, such as the TLV-STEL, for these chemicals generally restrict permissible contact with such chemicals to relatively low concentrations over relatively short contact durations (15 minutes in the case of the TLV-STEL).

Ahmed sees that although contact duration fundamentally affects how a substance affects you, an ALOHA footprint, by itself, doesn't tell him anything about this important piece of information. He wonders: Why isn't it possible to see a footprint showing the area where the LOC is exceeded for at least the contact duration? Wouldn't that make more sense than just showing the area where the LOC is predicted to be exceeded for any amount of time?

Actually, the situation is not that straightforward. Let's examine some ALOHA Concentration graphs to see why.

Some Concentration Graphs

Once ALOHA has displayed a footprint for a release scenario, you can easily obtain a Concentration graph, either (a) by double-clicking on any point in the footprint window or (b) by choosing Concentration from the Display menu and then indicating the coordinates of a location of concern. If you have placed a footprint on a map in MARPLOT, you can view a Concentration graph by clicking on a location of concern on the map, and then, from the ALOHA submenu in MARPLOT's Sharing menu, choosing Set Conc & Dose Point. (Check your ALOHA manual to learn more about viewing and using Concentration graphs.)

Figure 1, below, shows an example Concentration graph for an ammonia release. In this graph, the shaded, horizontal line represents the LOC, which in this case is ammonia's TLV-STEL of 35 ppm. A dotted line represents indoor concentration (in this case, the concentration inside single-storied, sheltered buildings with doors and windows closed), and a solid line represents outdoor concentration.

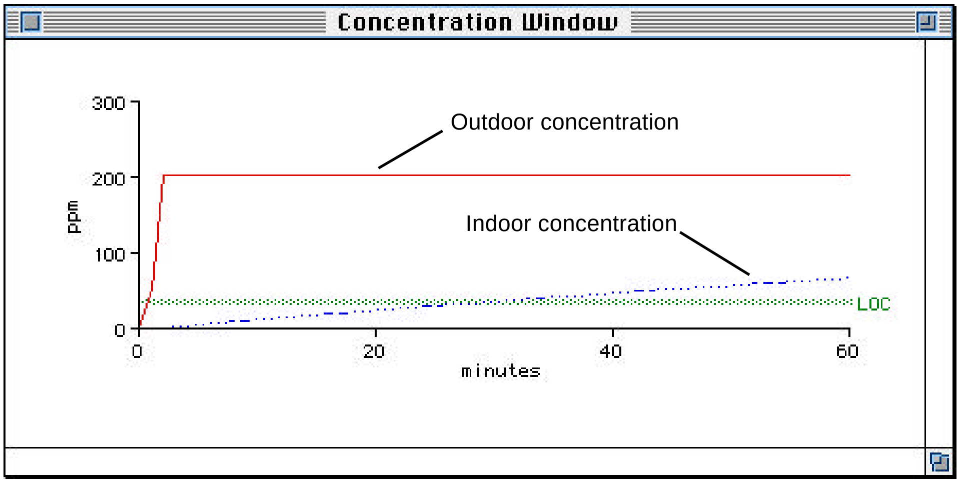

Figure 1. In this graph, the outdoor concentration exceeds the LOC for longer than the contact duration.

By examining the Concentration graph in Figure 1, you can see that the outdoor concentration line rises above the LOC line very soon after the release begins (it begins when the time on the horizontal axis equals 0 minutes), then remains above the line for nearly an hour. Eventually, it may remain above the LOC line for longer than an hour; ALOHA makes its predictions only for the first hour after the beginning of a release. This tells you that for this particular release, ALOHA predicts that the ammonia concentration outdoors, at the specified location, will remain above the LOC for longer than the 15-minute contact duration for TLV-STEL. That is, you can tell from this graph that ALOHA predicts that during this release, a clear hazard would exist to people who remain outdoors at this location. The indoor concentration rises above the LOC after about 30 minutes, and then continues to rise, indicating that at this location, ALOHA predicts that a clear hazard would exist indoors as well.

The Concentration graph in Figure 2 shows concentrations predicted for a different location. Here, the line representing the LOC of 35 ppm does not appear on the graph. This clues you in to the fact that during this release, ALOHA predicts that the ammonia concentration will never rise as high as the LOC. In fact, you can see from the graph that ALOHA predicts that the outdoor concentration will rise to a maximum of only about 4 ppm, slightly more than one-tenth of the LOC. This graph seems to suggest that people who remain outdoors at this location would not be exposed to a hazardous situation.

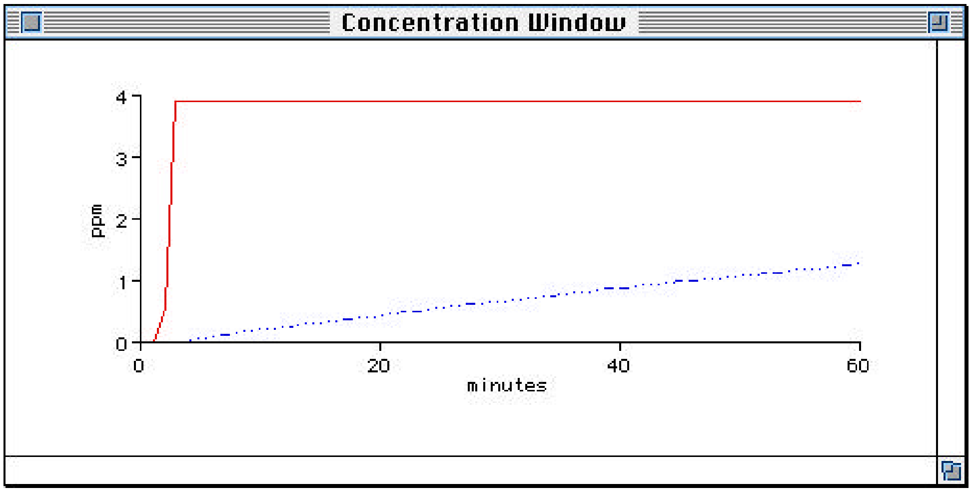

Figure 2. In this graph, the concentration never reaches the LOC.

The two graphs in Figures 1 and 2 represent cases where it may seem relatively easy to interpret a predicted situation as hazardous or nonhazardous, according to the definition of the LOC you're using. However, neither situation is as clear-cut as it may look. First, any Concentration graph represents only a ballpark estimate of what would happen in a real situation. In real life, the wind might change direction, speed up, or slow down, and the trajectory of the pollutant cloud might be affected by obstacles such as buildings or hills. Second, no exposure limit should be interpreted as a precise level above which everyone would experience the same toxic effects, and below which everyone would be safe. In any group of people, there are some people who are more vulnerable to a toxic chemical. Especially vulnerable people include the elderly and children, people who are sick, and pregnant women.

Figure 3, below, shows a Concentration graph for a different ammonia release. At this location, ALOHA predicts that the outdoor concentration will rise to a maximum value of about 82 ppm, more than twice as high as the LOC of 35 ppm. However, it would exceed the LOC for just 3 minutes, a much shorter time than the 15-minute contact duration.

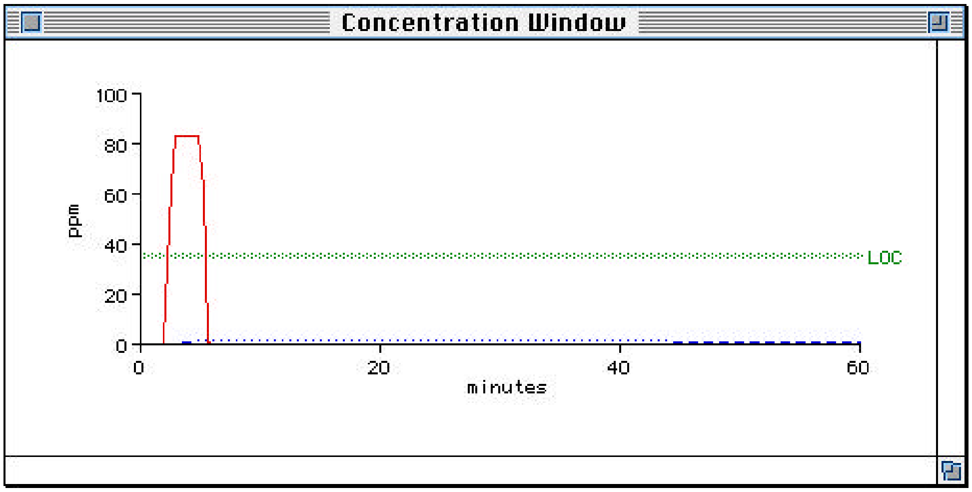

Figure 3. In this graph, the concentration exceeds the LOC, but for a shorter time interval than the contact duration.

Does this graph represent a hazardous situation for people who remain outdoors at this location? If you were to judge strictly according to the definition of TLV-STEL, you might determine that it is not hazardous, because the LOC wasn't exceeded for a full 15 minutes, and if you computed the time-weighted average concentration for the 15-minute period, you would find that it would be below the TLV-STEL of 35 ppm (you could compute the time-weighted average concentration as [(3 minutes * 82 ppm) + (12 minutes * 0 ppm)] / 15 minutes = 16.4 ppm). However, most of us wouldn't feel comfortable making such a judgment during a real response: the situation looks ambiguous. To make a good judgment about the situation represented by this graph, you would need to talk with a toxicology expert, perhaps a researcher at your local university or a toxicology professional at a government agency or research organization.

In short, in real-life situations, it's hard to tell for sure whether a particular exposure to a toxin would be hazardous or not. To reduce just this kind of confusion, the National Institute for Safety and Health (NIOSH) recently removed the contact duration that had been associated with the IDLH (Immediately Dangerous to Life and Health) exposure guideline. NIOSH recommends that if workers are exposed to a concentration as high as the IDLH for a chemical, they should leave the contaminated area immediately, and not assume that they have a 30-minute "grace period." Bear this recommendation in mind if you use IDLH as your LOC in ALOHA. Because IDLH is the built-in LOC for many ALOHA chemicals, when you run a scenario in ALOHA, it automatically uses your selected chemical's IDLH unless you type in a different LOC or no IDLH has been established for that chemical.

Ahmed now realizes that ALOHA does not account for contact duration when it displays a footprint for an LOC with a contact duration because there's just no simple way for ALOHA to distinguish between hazardous and nonhazardous areas. Instead, it does the next best thing: it shows you a footprint that represents its “best guess” of the area where a toxic hazard may potentially exist. To use ALOHA most effectively and best understand the hazard posed by a particular release, use the Concentration option to view Concentration graphs at a sampling of points within the footprint. As you do so, bear in mind that ALOHA’s footprint represents the area where concentrations may exceed the LOC *as long as the wind does not shift direction*. If the wind changes to blow in a different direction, type the new direction into ALOHA and run your scenario again. And above all, remember that all estimates from ALOHA—or any other model—represent best guesses, not exact values.

....

Prepared by: Modeling and Simulation Studies Branch, Hazardous Materials Response and Assessment Division, National Oceanic and Atmospheric Administration, Seattle, WA 98115.